Aeroelastic problem with two degrees of freedom Turbulent and laminar computations

Abstract

This report includes the formulation of the two dimensional aeroelastic problem with structure with three degrees of freedom.

Contents

1 Mathematical models

1.1 Fluid models

- laminar model
- RANS + Spallart Almaras turbulence model
- RANS + algebraic turbulence model

1.2 STRUCTURE MODEL (VKR40)

$$m\ddot{h} + k_{hh}h + S_\alpha\,\ddot{\alpha}\,\cos\alpha - S_\alpha\dot{\alpha}^2\sin\alpha + d_{hh}\dot{h} = -L(t),$$
$$S_\alpha\ddot{h}\cos\alpha + I_\alpha\ddot{\alpha} + k_{\alpha\alpha}\alpha + d_{\alpha\alpha}\dot{\alpha} = M(t),$$

$$\begin{aligned}
m &= 0.086622\ \text{kg}\\
S_\alpha &= -0.000779673\ \text{kg m}\\
I_\alpha &= 0.000487291\ \text{kg m}^2,\\
k_{hh} &= 105.109\ \text{N/m},\\
k_{\alpha\alpha} &= 3.695582\ \text{N m/rad},\\
l &= 0.05\ \text{m},\\
c &= 0.3\ \text{m},\\
\rho &= 1.225\ \text{kg/m}^3,\\
\nu &= 1.5\cdot 10^{-5}\ \text{m/s}^2
\end{aligned}$$

1.3 STRUCTURE MODEL (VKR30)

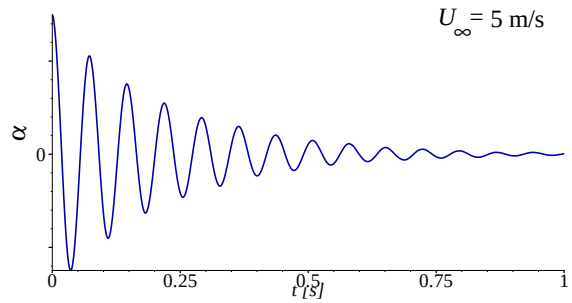
$$m\ddot{h} + k_{hh}h + S_\alpha\,\ddot{\alpha}\,\cos\alpha - S_\alpha\dot{\alpha}^2\sin\alpha + d_{hh}\dot{h} = -L(t),$$
$$S_\alpha\ddot{h}\cos\alpha + I_\alpha\ddot{\alpha} + k_{\alpha\alpha}\alpha + d_{\alpha\alpha}\dot{\alpha} = M(t),$$

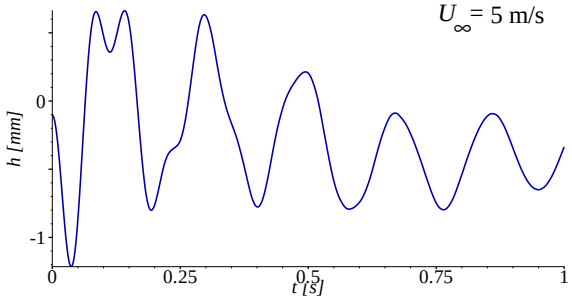
$$\begin{aligned}
m &= 0.086622\ \text{kg}\\
S_\alpha &= 0.000779673\ \text{kg m}\\
I_\alpha &= 0.000487291\ \text{kg m}^2,\\
k_{hh} &= 105.109\ \text{N/m},\\
k_{\alpha\alpha} &= 3.695582\ \text{N m/rad},\\
l &= 0.05\ \text{m},\\
c &= 0.3\ \text{m},\\
\rho &= 1.225\ \text{kg/m}^3,\\
\nu &= 1.5\cdot 10^{-5}\ \text{m/s}^2
\end{aligned}$$

2 VKR 30/VKR 30T

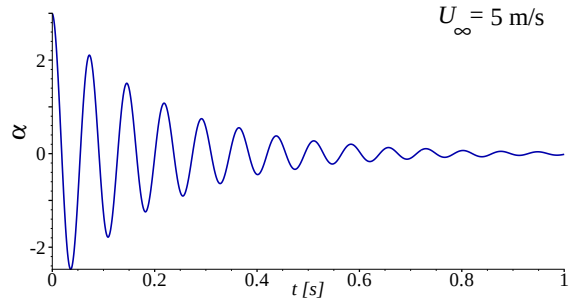
2.1 5 m/s

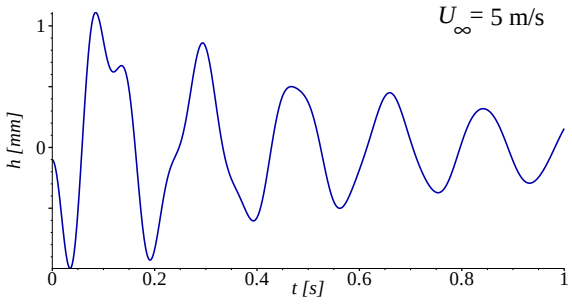
LAMINAR





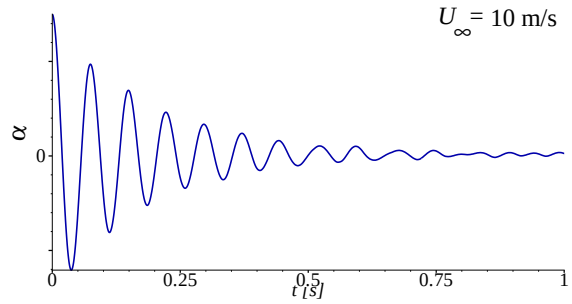
TURBULENT

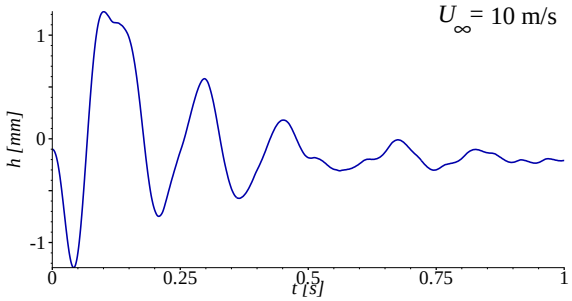




2.2 10 m/s

LAMINAR





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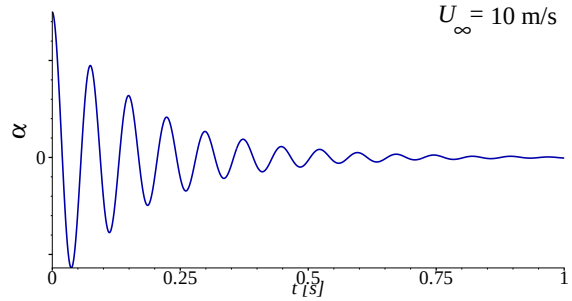
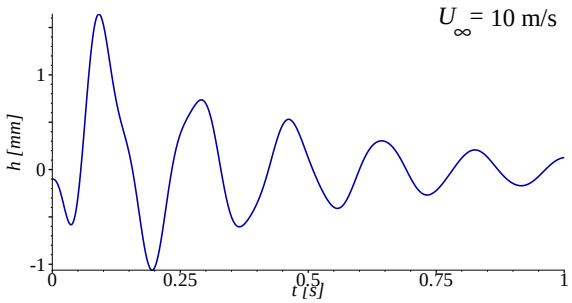
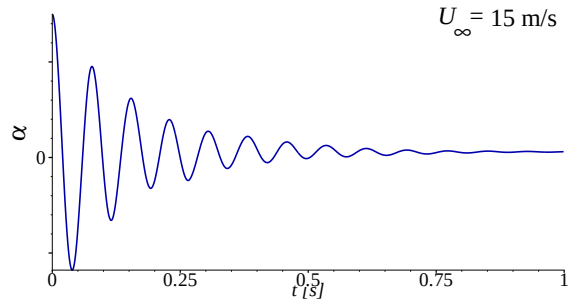
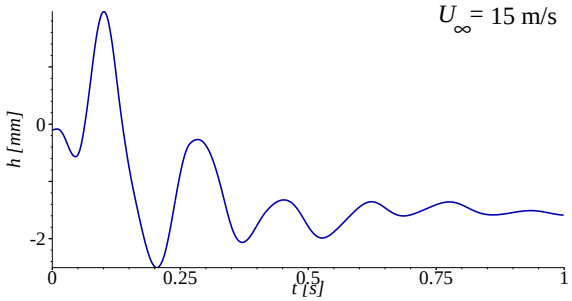




2.3 15 m/s

LAMINAR





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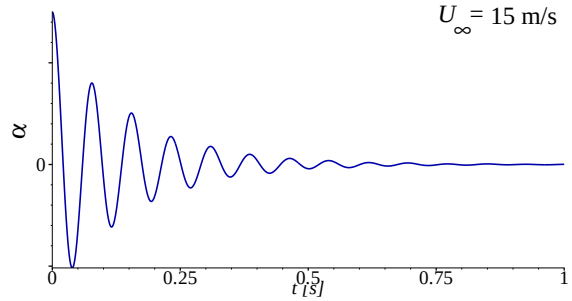
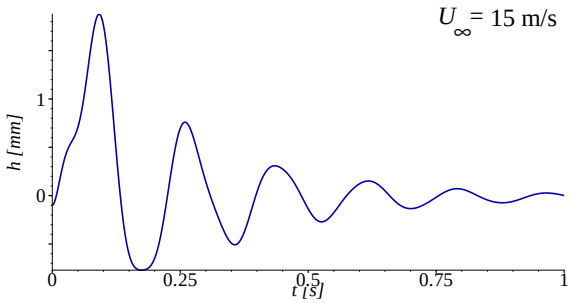
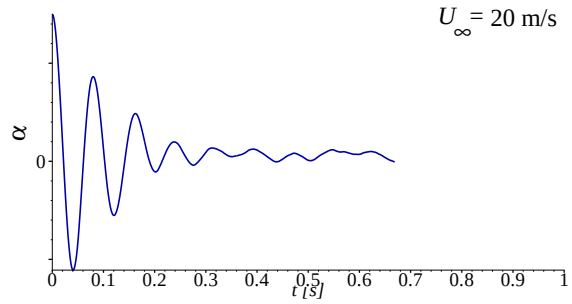
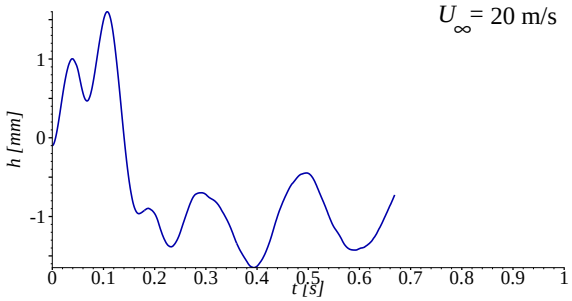




2.4 20 m/s

LAMINAR





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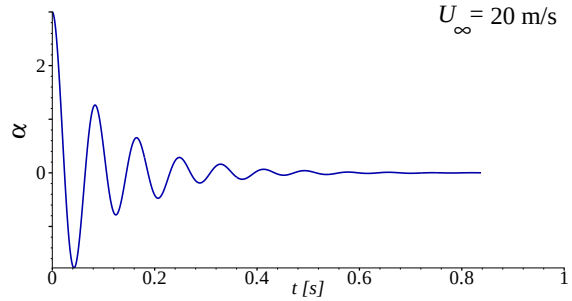
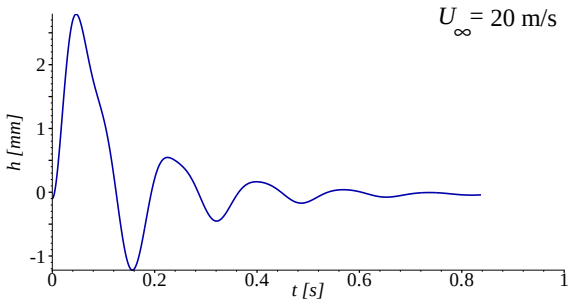
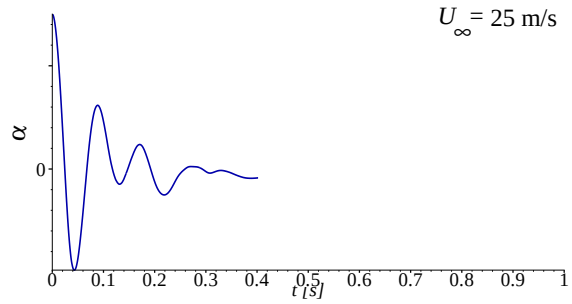
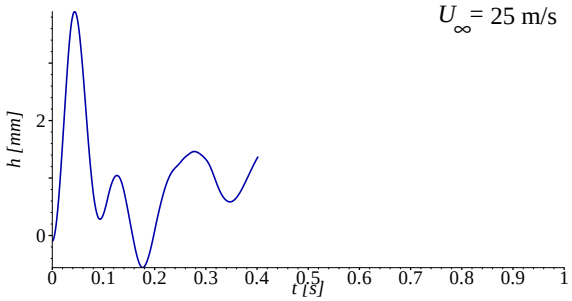




2.5 25 m/s

LAMINAR





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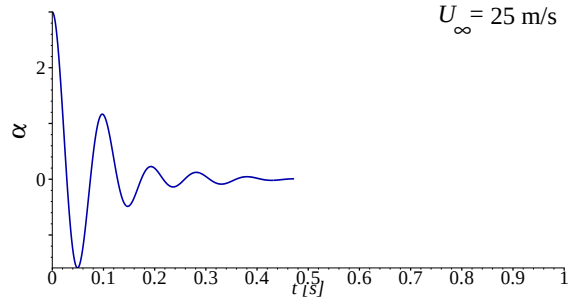
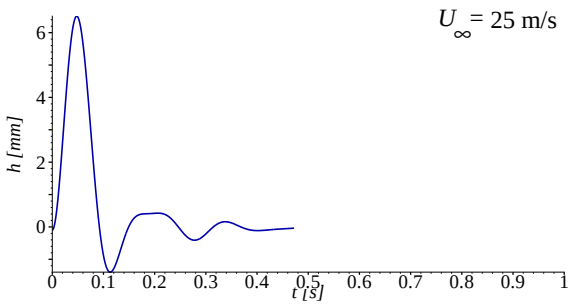
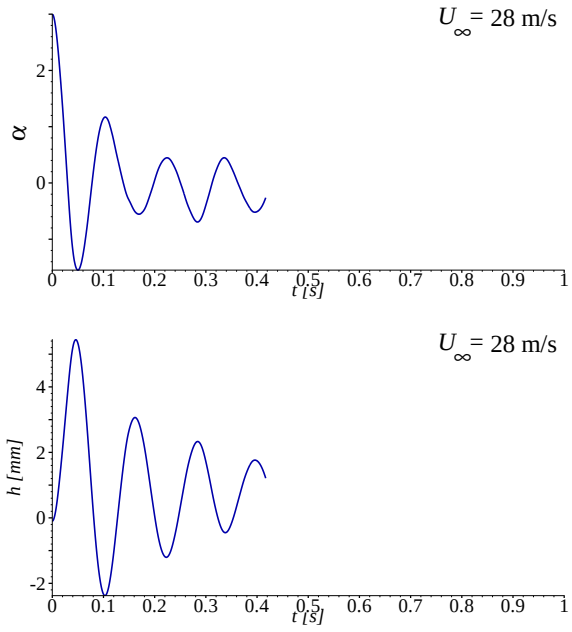




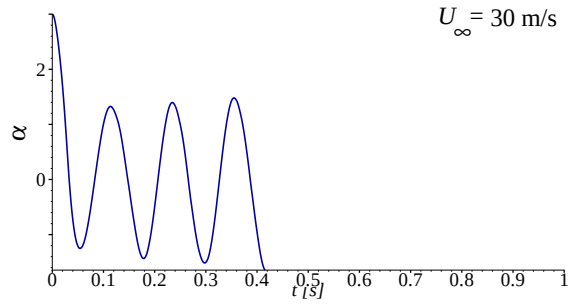
2.6 28 m/s

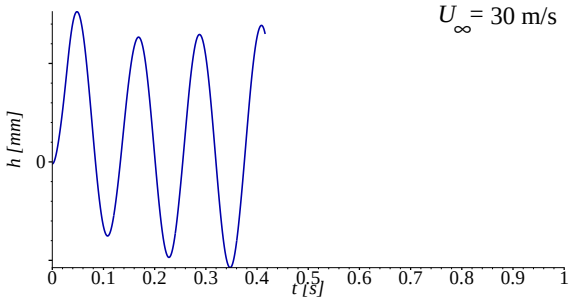
LAMINAR



2.7 30 m/s

LAMINAR





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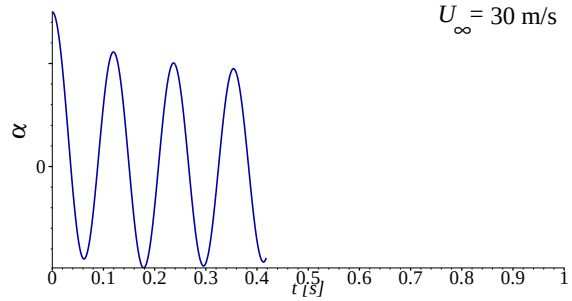
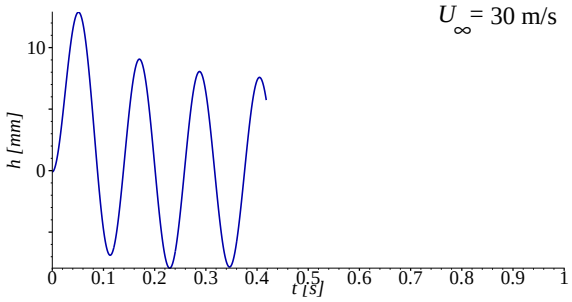
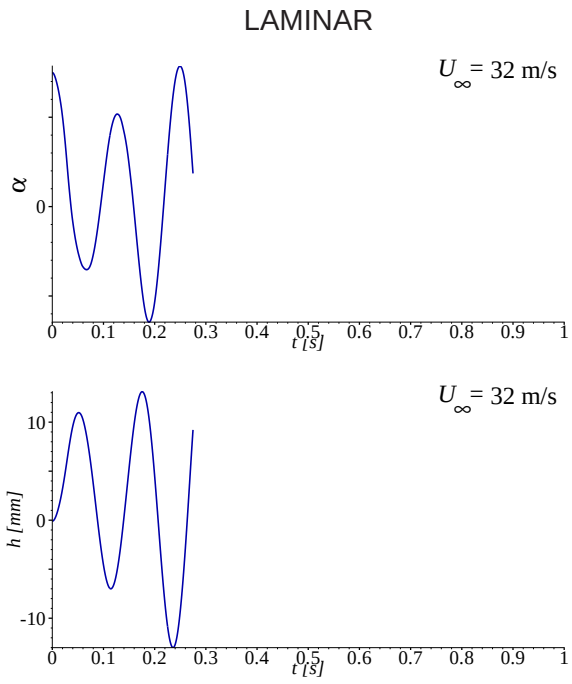




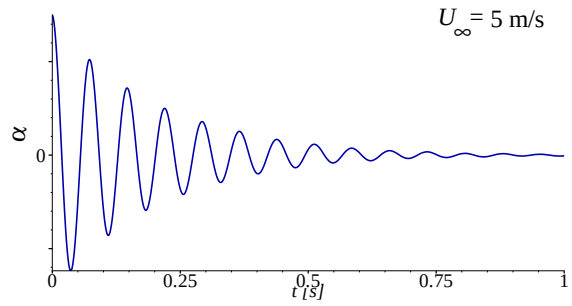
2.8 32 m/s

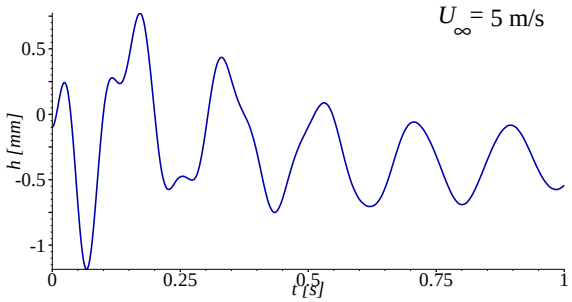

LAMINAR
U_∞ = 32 m/s
α
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
t [s]
U_∞ = 32 m/s
10
0
-10
h [mm]
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
t [s]

3 VKR40/VKR40T

3.1 5 m/s

LAMINAR





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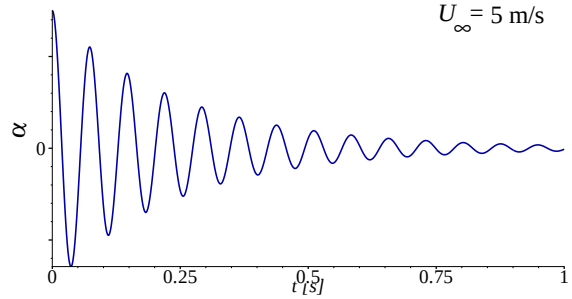
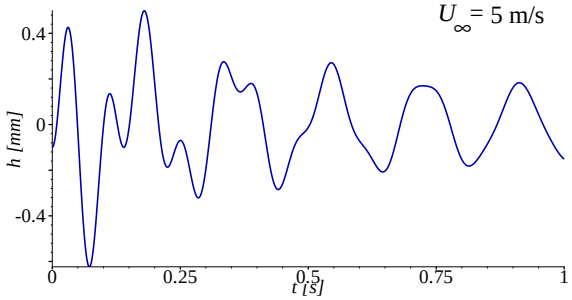
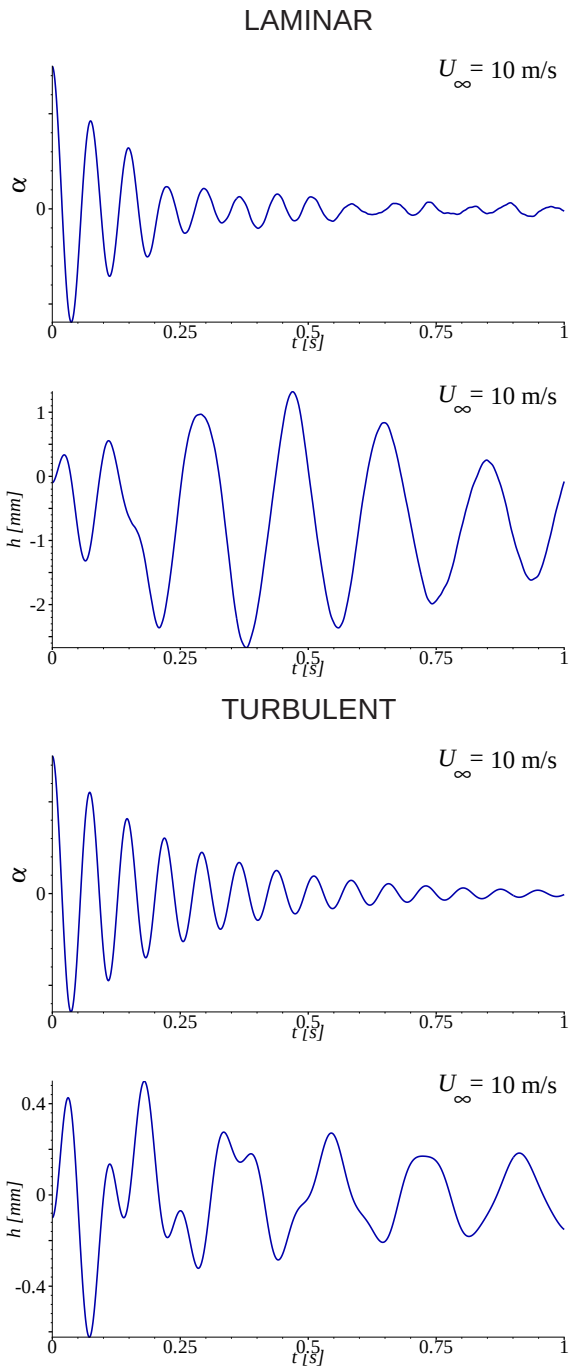
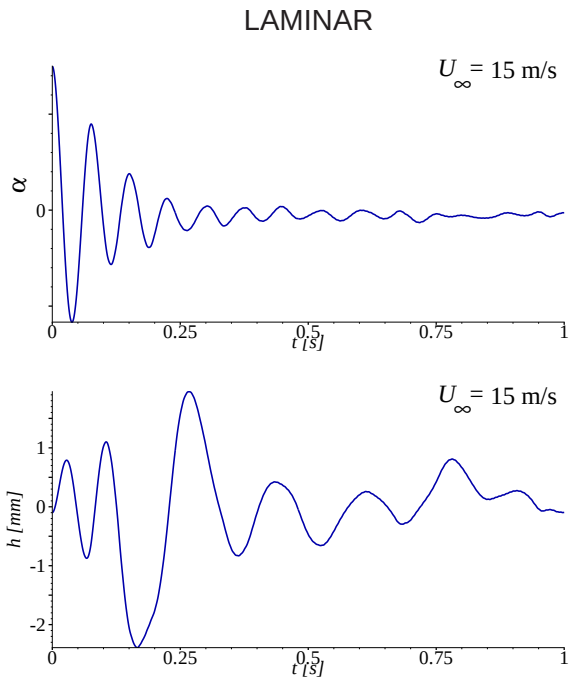




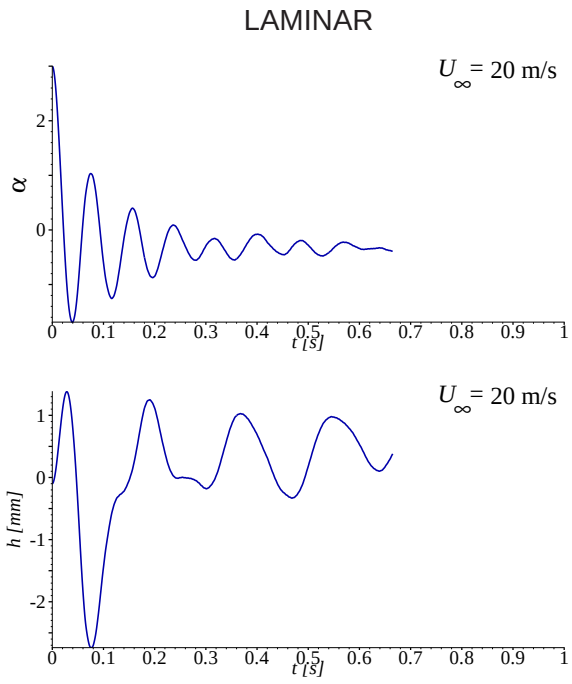
3.2 10 m/s


LAMINAR
U_∞ = 10 m/s
α
0
0
0.25
0.5
0.75
1
t [s]
U_∞ = 10 m/s
h [mm]
1
0
-1
-2
0
0.25
0.5
0.75
1
t [s]
TURBULENT
U_∞ = 10 m/s
α
0
0
0.25
0.5
0.75
1
t [s]
U_∞ = 10 m/s
h [mm]
0.4
0
-0.4
0
0.25
0.5
0.75
1
t [s]

3.3 15 m/s

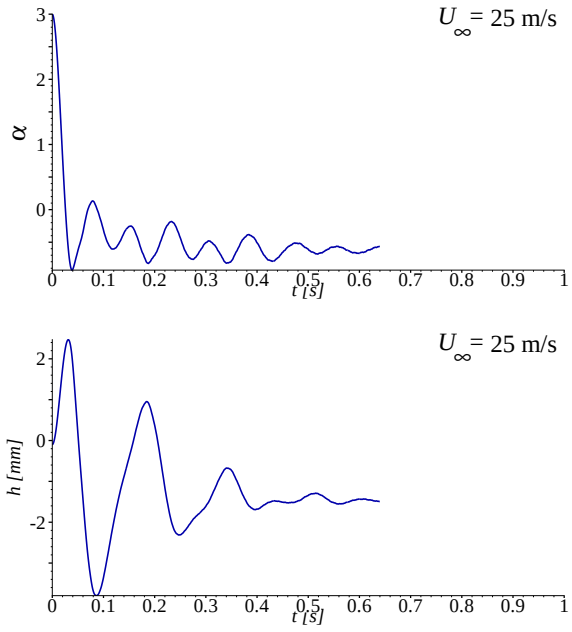

LAMINAR
U_∞ = 15 m/s
α
0
0
0.25
0.5
0.75
1
t [s]
U_∞ = 15 m/s
h [mm]
1
0
-1
-2
0
0.25
0.5
0.75
1
t [s]

3.4 20 m/s

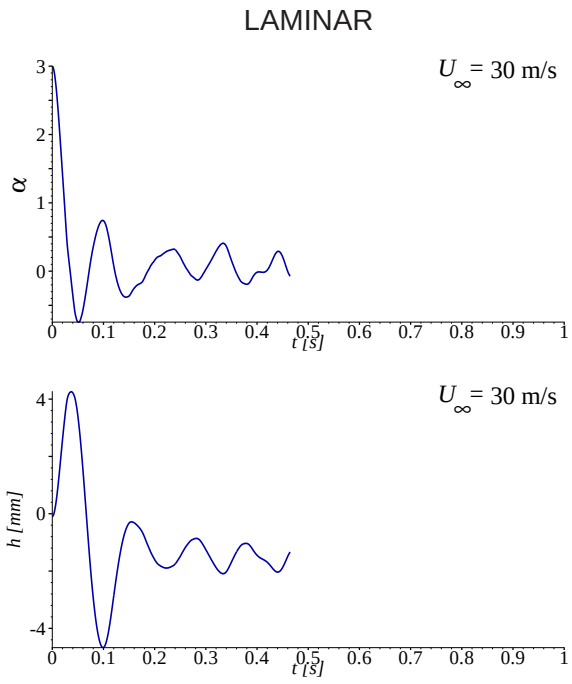

LAMINAR
U_∞ = 20 m/s
α
2
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
t [s]
U_∞ = 20 m/s
h [mm]
1
0
-1
-2
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
t [s]

3.5 25 m/s

LAMINAR

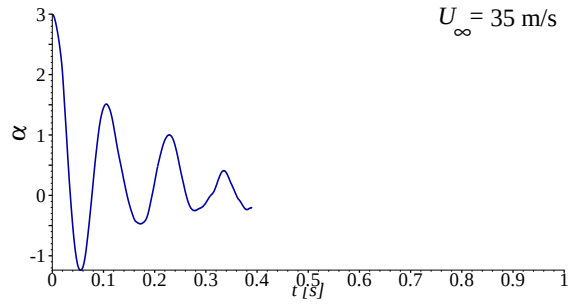


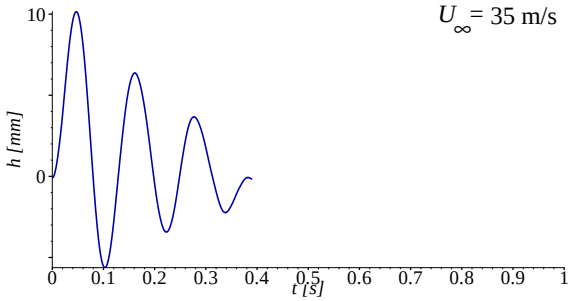
3.6 30 m/s



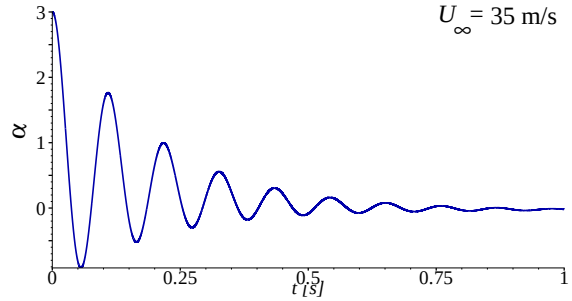
3.7 35 m/s

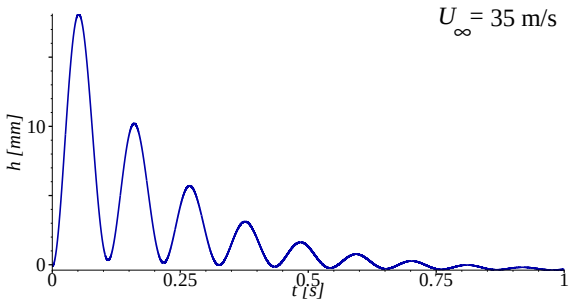
LAMINAR





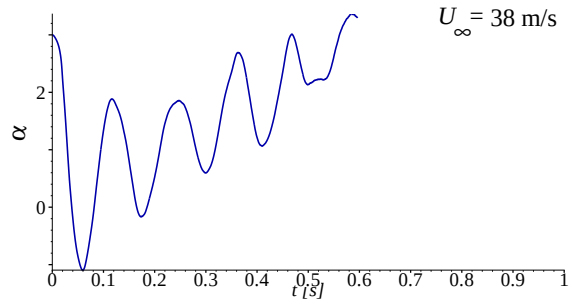
TURBULENT

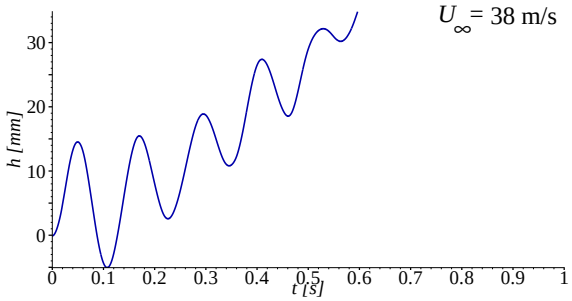




3.8 38 m/s

LAMINAR





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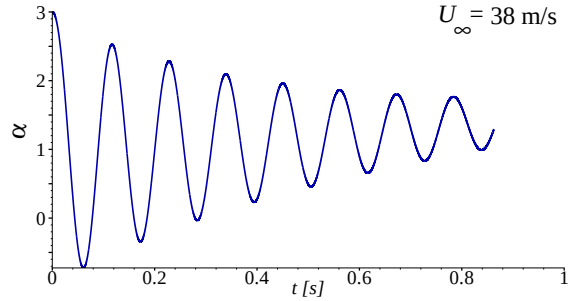
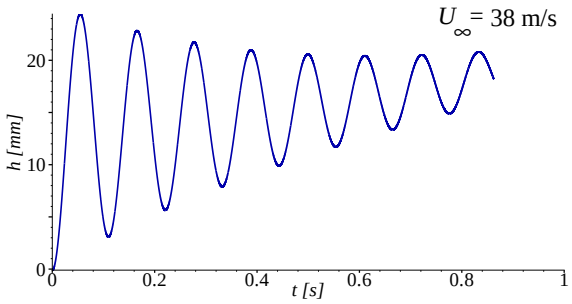
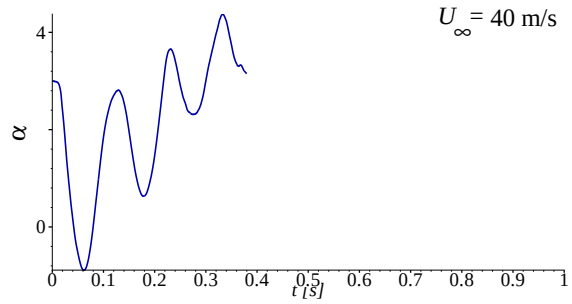
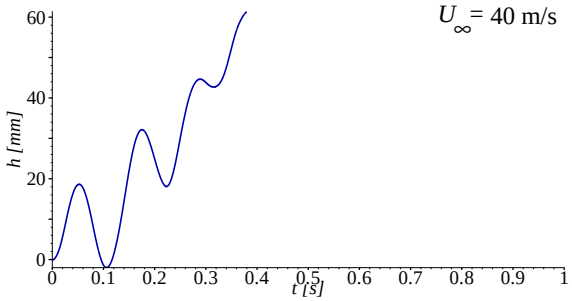




3.9 40 m/s

LAMINAR





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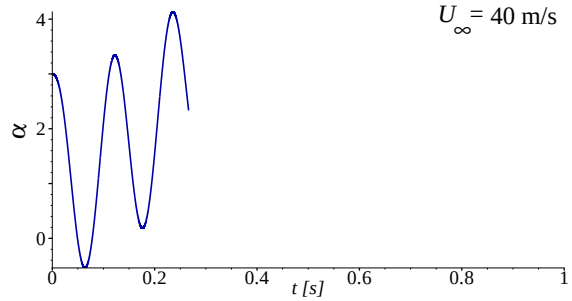
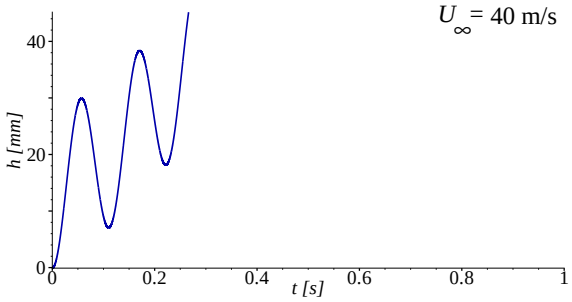
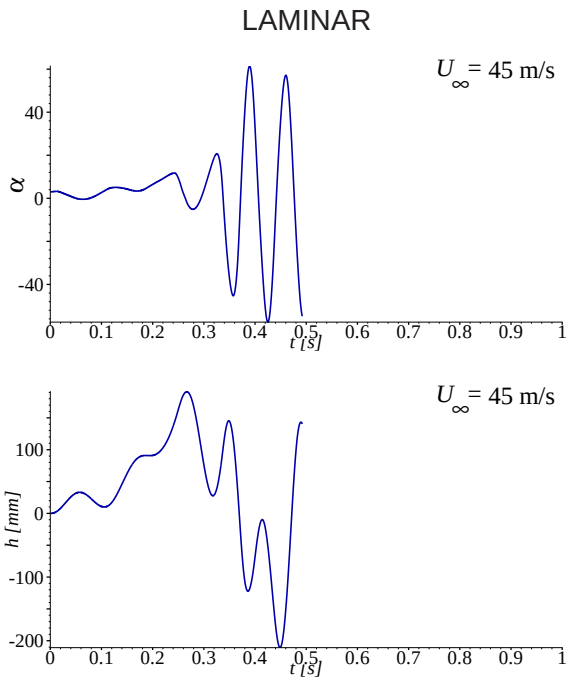




3.10 45 m/s


LAMINAR
U_∞ = 45 m/s
α
40
0
-40
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
t [s]
U_∞ = 45 m/s
h [mm]
100
0
-100
-200
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
t [s]